Name _____

Using Chi Square Test to Determine Inheritance Patterns

Use of the Chi Square Test

- You are trying to determine if the data provided follows a particular inheritance pattern
- In other words, are the differences in the observed data due solely to chance?
    - If so, that inheritance pattern is a GOOD FIT for the data
    - If not, the inheritance pattern is a POOR FIT for the data
        - In the case of a single gene
            - Perhaps another type of inheritance is at work
        - In the case of two or more genes
            - Perhaps the genes do NOT assort independently (and are therefore linked in some way)

State your Null Hypothesis:

- You are making a prediction about
    - The type of inheritance
    - The genotypes of the parents being crossed
    - The expected phenotypic ratio of the resulting offspring
- In problems involving multiple genes, you may even be trying to determine if the observed data follows Mendel's Laws
    - You start by assuming the genes assort independently
    - If that null hypothesis is rejected, then the genes may be linked

Calculate your Chi-Squared Value:

- Formalize your thinking by making a "contingency box" with the expected and observed values
    - The observed values are stated in the problem
    - The expected values are calculated based on the expected phenotypic ratio
        - Determine the expected probability of each phenotype
            - Based on Punnett squares and/or the rules of probability!
        - Multiply the expected probability by the total number of offspring
- Plug your observed and expected values into the chi-square formula
- Determine the critical chi-square value
    - Determine the degrees of freedom (# of categories – 1)
    - Use a p-value of 0.05 in the chi-square table

$$\chi^2 = \sum \frac{(\text{Observed Value} - \text{Expected Value})^2}{(\text{Expected Value})}$$

p value	Degrees of Freedom							
	1	2	3	4	5	6	7	8
0.05	3.84	5.99	7.82	9.49	11.07	12.59	14.07	15.51
0.01	6.64	9.21	11.34	13.28	15.09	16.81	48.48	20.09

Draw your Conclusion

- If the calculated chi-square value is <u>less than</u> the critical value from the table, then we **accept** (or fail to reject) the null hypothesis
    - Thus there is NO statistically significant difference between our observed numbers and our expected numbers
        - Any difference is due to chance!
    - That means our predicted inheritance pattern/genotypes of parents is a GOOD FIT for the data

- If the calculated chi-square value is <u>greater than or equal to</u> the critical value from the table, then the null hypothesis is **rejected**
    - Thus the difference between our observed numbers and our expected numbers IS statistically significant
        - The difference is due to something other than chance
    - That means our predicted inheritance pattern/genotypes of parents is a POOR FIT for the data
        - In the case of a single gene
            - Perhaps another type of inheritance is at work
        - In the case of two or more genes
            - Perhaps the genes do NOT assort independently and are therefore linked

TIPS

- Be familiar with the following inheritance patterns
    - Complete dominance
    - Incomplete dominance
    - Codominance
    - Multiple alleles
    - Polygenic
    - Sex-linked
- Know what phenotypic ratios result from particular crosses
    - True breeding vs hybrid
    - Monohybrid vs dihybrid
    - Autosomal vs sex linked
- Common expected ratios are
    - 1:1 or 3:1 or 1:2:1 or 2:1:1
    - 1:1:1:1 or 9:3:3:1
        - Be aware that the observed ratios will not match these exactly!
        - Go with the closest approximation

SAMPLE PROBLEMS

1. Problem: In a certain species of plant, the allele to produce green melons (G) is dominant over the allele to produce yellow melons (g). A student performed a cross between a plant that produced green melons and a plant that produced yellow melons. When the student observed the next generation, the 94 seeds that were produced from the cross matured into 53 plants with green melons and 41 plants with yellow melons.

State your Null Hypothesis:

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Calculate your Chi-Squared Value:

- Formalize your thinking by making a contingency box
  - Use information in problem as observed results
  - To calculate expected results:
    - If the two parents you predicted were crossed, what is the probability that the offspring would have each phenotype?

    - Multiply this fraction by the total number of offspring produced

- Calculate your chi-square value
  - Show your work:
  - Chi-square value =
- Determine the critical chi-square value (use a p-value of 0.05)
  - Degrees of freedom =
  - Critical chi-square value =

Draw your Conclusion

- Our calculated chi-square value is _____ than our critical chi-square value
- Therefore, we _____ our null hypothesis which means
  -
    -
  -

2. In one particular species of plant, purple flowers (P) are dominant over red flowers (p) and long pollen grains (L) are dominant over round pollen grains (l). After crossing true breeding plants that have purple flowers and long pollen grains with true breeding plants that have red flowers and round pollen grains, the resulting dihybrids (PpLl) were then crossed. Of the resulting 381offspring, 284 had purple flowers and long pollen grains, 21 had purple flowers and round pollen grains, 21 had red flowers and long pollen grains, and 55 had red flowers and round pollen grains.

State your Null Hypothesis:

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Calculate your Chi-Squared Value:

- Formalize your thinking by making a contingency box
  - Use information in problem as observed results
  - To calculate expected results:
    - What is the probability that the offspring would have each phenotype?
    - Multiply this fraction by the total number of offspring produced

- Calculate your chi-square value
  - Show your work:
  - Chi-square value =

- Determine the critical chi-square value (use a p-value of 0.05)
  - Degrees of freedom =
  - Critical chi-square value =

Draw your Conclusion

- Our calculated chi-square value is _____ than our critical chi-square value
- Therefore, we _____ our null hypothesis which means
  -
  -
    -

3. Problem: In corn, purple seeds (P) are dominant over yellow seeds (p) and starchy seeds (S) are dominant over sweet seeds (s). (Note: Starchy seeds appear smooth while sweet seeds appear shrunken). A particular ear of corn has a total of 433 seeds, including 250 Purple & starchy, 75 Purple & sweet, 85 Yellow & starchy, and 23 Yellow & sweet.

State your Null Hypothesis:

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Calculate your Chi-Squared Value:

- Formalize your thinking by making a contingency box
  - Use information in problem as observed results
  - To calculate expected results:
    - What is the probability that the offspring would have each phenotype?
    - Multiply this fraction by the total number of offspring produced

- Calculate your chi-square value
  - Show your work:
  - Chi-square value =

- Determine the critical chi-square value (use a p-value of 0.05)
  - Degrees of freedom =
  - Critical chi-square value =

Draw your Conclusion

- Our calculated chi-square value is _____ than our critical chi-square value
- Therefore, we _____ our null hypothesis which means
  -
    -
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    -

4. Problem: In a certain reptile, eyes can be either black or yellow. Two black eyed lizards are crossed, and the result is 72 black eyed lizards, and 28 yellow-eyed lizards.

State your Null Hypothesis:

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Calculate your Chi-Squared Value:

- Formalize your thinking by making a contingency box
  - Use information in problem as observed results
  - To calculate expected results:
    - If the two parents you predicted were crossed, what is the probability that the offspring would have each phenotype?

    - Multiply this fraction by the total number of offspring produced

- Calculate your chi-square value
  - Show your work:
  - Chi-square value =
- Determine the critical chi-square value (use a p-value of 0.05)
  - Degrees of freedom =
  - Critical chi-square value =

Draw your Conclusion

- Our calculated chi-square value is _____ than our critical chi-square value
- Therefore, we _____ our null hypothesis which means
  -
    -
  -

5. Problem: A sample of mice (all from the same parents) shows 58 with black hair and black eyes, 16 with black hair and red eyes, 19 with white hair and black eyes, and 7 with white hair and red eyes.

State your Null Hypothesis:

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Calculate your Chi-Squared Value:

- Formalize your thinking by making a contingency box
  - Use information in problem as observed results
  - To calculate expected results:
    - What is the probability that the offspring would have each phenotype?

    - Multiply this fraction by the total number of offspring produced

- Calculate your chi-square value
  - Show your work:

  - Chi-square value =

- Determine the critical chi-square value (use a p-value of 0.05)
  - Degrees of freedom =
  - Critical chi-square value =

Draw your Conclusion

- Our calculated chi-square value is _____ than our critical chi-square value
- Therefore, we _____ our null hypothesis which means
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Name _____

MORE CHI SQUARE PRACTICE

1. A newly identified fruit fly mutation, bloodshot eyes, is hypothesized to be autosomal recessive. The experimenter crossed two fruit flies that were heterozygous for the trait. The next generation produced 75 wild-type males, 60 wild-type females, 31 bloodshot males, and 45 bloodshot females. Does this data support or reject the hypothesis? Support your answer using χ^2 analysis.

   Null Hypothesis:

   Chi Square Calculations:

   Conclusion:

2. In the garden pea, yellow cotyledon color is dominant to green, and inflated pod shape is dominant to the constricted form. Considering both of these traits jointly in self-fertilized dihybrids, the offspring appeared in the following numbers:
    - 193 green, inflated
    - 184 yellow, constricted
    - 556 yellow, inflated
    - 61 green, constricted

    Do these genes assort independently? Support your answer using χ^2 analysis.

    Null Hypothesis:

    Chi Square Calculations:

    Conclusion:

3. True-breeding red birds are crossed with true-breeding blue birds. The resulting F_1 offspring are all purple. Two purple birds are then crossed, and the resulting offspring in the F_2 generation included 7 red birds, 22 purple birds, and 11 blue birds. What type of inheritance is at work? Support your answer using χ^2 analysis.

Null Hypothesis:

Chi Square Calculations:

Conclusion:

4. In fruit flies, red eyes are dominant over purple eyes and normal wings are dominant over vestigial wings. Females that are heterozygous for both red eyes and normal wings are crossed with males that are homozygous for both purple eyes and vestigial wings. Of 2839 offspring, 1339 have red eyes and normal wings, 151 have red eyes and vestigial wings, 154 have purple eyes and normal wings, and 1195 have purple eyes and vestigial wings. Do these genes assort independently? Support your answer using χ^2 analysis.

   Null Hypothesis:

   Chi Square Calculations:

   Conclusion:

5. Bow-legs is hypothesized to be X-linked recessive in *Drosophila melanogaster* (fruit flies). A heterozygous wild-type female is crossed with a wild-type male. Of the resulting offspring, 75 were wild-type females, 30 were wild-type males, 40 were bow-legged males, and there were no bow-legged females. Does this data support or reject the hypothesis? Support your answer using χ^2 analysis.

Null Hypothesis:

Chi Square Calculations:

Conclusion: